Chapter 8. Regional Survey off San Diego Sediment Characteristics

INTRODUCTION

The City of San Diego has conducted summer regional surveys of sediment conditions on the mainland shelf off San Diego since 1994 in order to evaluate physical and chemical patterns and trends over a large geographic area. Such region-wide monitoring is designed to assess the quality and characteristics of sediments, as well as provide additional information that may help to differentiate reference areas from sites impacted by wastewater and stormwater discharge. These annual surveys are based on an array of stations randomly selected for each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. The 1994, 1998, and 2003 surveys were conducted as part of the Southern California Bight 1994 Pilot Project (SCBPP), and the Southern California Bight 1998 and 2003 Regional Monitoring Programs (Bight′98 and Bight′03, respectively). These large-scale surveys included other major southern California dischargers, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, U.S.A.). The same randomized sampling design was used for the random sampling surveys limited to the San Diego region (1995–1997, 1999–2002). A regional (random) survey was not conducted in 2004 in order to conduct a special strategic process study pursuant to an agreement with the SDRWQCB and USEPA (see City of San Diego 2005). The results from Phase I of the San Diego Sediment Mapping Study are currently being analyzed (see Stebbins et al. 2004). In July 2005, the City revisited the 1995 survey sites in order to compare conditions 10 years later.

This chapter presents analyses of sediment particle size and chemistry data collected during the San Diego regional survey of 2005. Descriptions and comparisons of the sediment conditions present in 2005 are included with analyses of levels and patterns of contamination relative to known and presumed sources. Results from the 2005 survey are compared to those of the 1995 survey.

MATERIALS AND METHODS

The July 2005 survey of randomly selected sites off San Diego covered an area from Del Mar south to the United States/Mexico border (**Figure 8.1**). This survey revisited the sites selected for the 1995 regional survey, which was based on the USEPA probability-based EMAP sampling design. Site selection involved a hexagonal grid that was randomly placed over a map of the region. One sample site was then randomly selected from within each grid cell. This randomization helps to ensure an unbiased estimate of ecological condition. The area sampled included the section of the mainland shelf from nearshore to shallow slope depths (12–202 m). Although 40 sites were initially selected for the 1995 and 2005 surveys, sampling at 3 sites in 1995 and 4 sites in 2005 was unsuccessful due to the presence of a rocky reefs.

Benthic sediment samples were collected using a modified 0.1-m^2 chain-rigged van Veen grab. Sub-samples were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987). All sediment analyses were performed at the City of San Diego Wastewater Chemistry Laboratory. Particle size analyses were performed using a Horiba LA-920 laser analyzer, which measures particles ranging in size from 0.00049–2.0 mm (i.e., -1 to 11 phi). Sand was defined as particles ranging in size >0.0625 mm, silt as particles from <0.0625 to 0.0039 mm, and clay as particles <0.0039 phi (**Table 8.1**). Coarse sediments (e.g., gravel, pebble, shell hash) were removed from each sample prior to analysis by screening the samples through a 2.0 mm mesh sieve. The retained material was weighed and expressed as the percent coarse of the total sample sieved. All of these data were standardized to obtain a distribution of coarse, sand, silt, and clay totaling 100%. The clay and silt

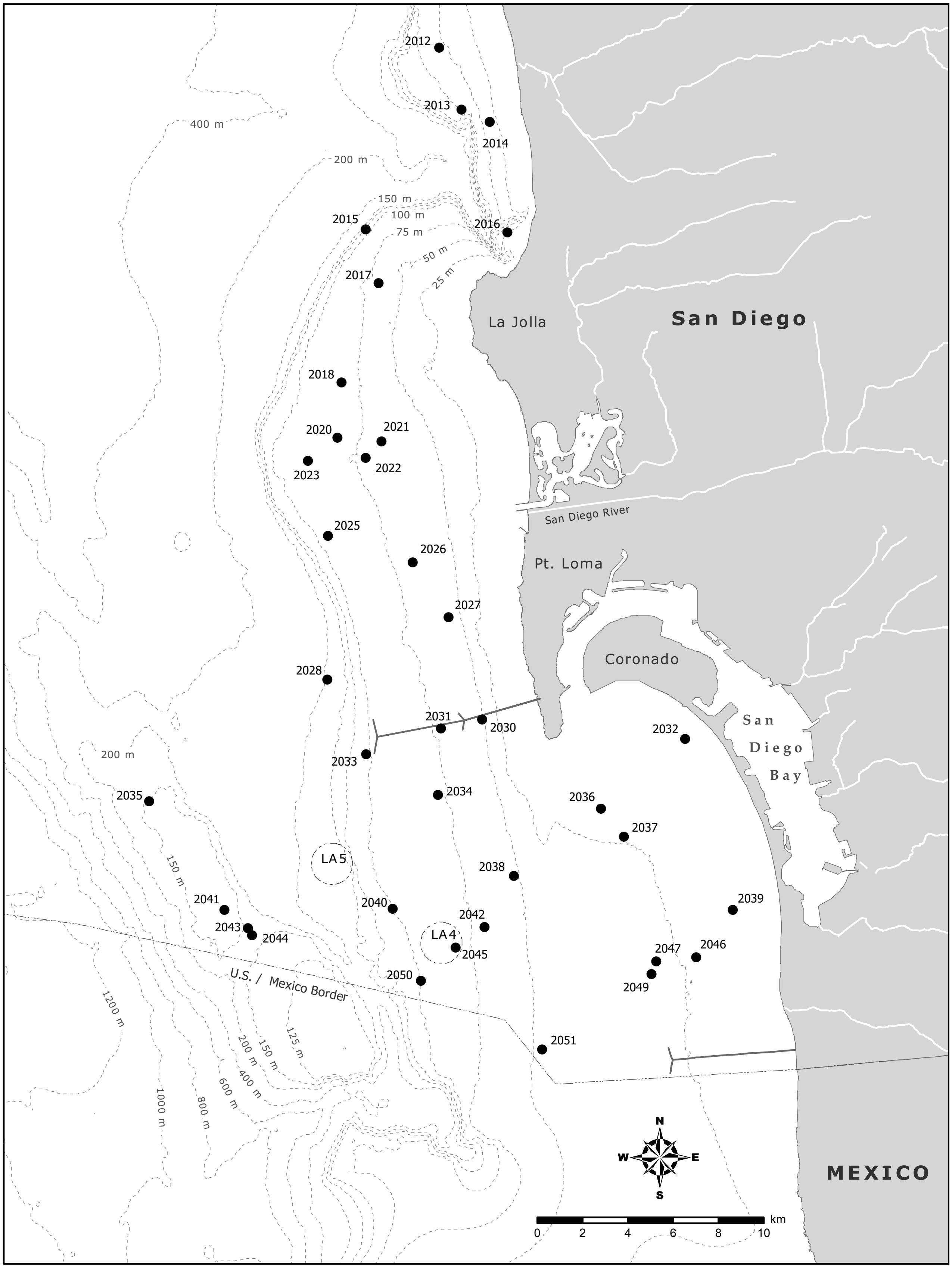

Figure 8.1
Randomly selected regional sediment quality stations (numbered stations) sampled off San Diego, CA (July 1995, 2005), including the semi-annual sampling grid for the South Bay Ocean Outfall (I stations).

Table 8.1

A subset of the Wentworth scale representative of the sediments encountered in the SBOO region. Particle size is presented in phi, microns, and millimeters along with the conversion algorithms. The sorting coefficients (standard deviation in phi units) are based on categories described by Folk (1968).

Wentworth scale				Sorting coefficient	
Phi Size	Microns	Millimeters	Description	Standard deviation	Sorting
-2	4000	4	Pebble	Under 0.35 phi	very well sorted
-1	2000	2	Granule	0.35–0.50 phi	well sorted
0	1000	1	Very coarse sand	0.50–0.71 phi	moderately well sorted
1	500	0.5	Coarse sand	0.71–1.00 phi	moderately sorted
2	250	0.25	Medium sand	1.00–2.00 phi	poorly sorted
3	125	0.125	Fine sand	2.00–4.00 phi	very poorly sorted
4	62.5	0.0625	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31	0.0310	Coarse silt		
6	15.6	0.0156	Medium silt		
7	7.8	0.0078	Fine Silt		
8	3.9	0.0039	Very fine silt		
9	2	0.0020	Clay		
10	0.98	0.00098	Clay		
11	0.49	0.00049	Clay		

Conversions for Diameter in Phi to Millimeters: D(mm) = 2-phi

Conversions for Diameter in Millimeters to Phi: D(phi) = $-3.3219\log_{10}$D(mm)

fractions were then combined to yield the percent "fines". Sediment particle size parameters were summarized according to calculations based on a normal probability scale with the sieved coarse fraction included with the >2 mm fraction (see Folk 1968). The calculated parameters include median and mean particle size in millimeters and phi, sorting coefficient (standard deviation), skewness, kurtosis and percent sediment type (i.e., coarse particles, sand, silt, clay).

The following sediment chemical parameters were analyzed: total organic carbon (TOC), total nitrogen (TN), total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyl compounds (PCBs). These data generally were limited to values above method detection limits (MDLs). However, the presence of some parameters (e.g., PAH compounds) detected at concentrations below their MDL were confirmed with high confidence by mass-spectrometry (i.e., peaks are confirmed by MS). These data were included as estimated values. Null (i.e., zero) values represent instances where the substance was either not detected, or detected below the MDL but not be confirmed by MS. Zeros were substituted for null values when estimating mean values. The data are summarized by depth strata used in the Bight'98 and Bight'03 regional surveys of the entire Southern California Bight (SCB): shallow shelf, 5–30 m; mid-shelf, 30–120 m; deep shelf, 120–200 m.

Cumulative distribution functions (CDFs) for TOC, TN, trace metals, and pesticides (i.e., DDT) were established previously for the SCB using data from the SCBPP (see Schiff and Gossett 1998). These reference values for these sediment chemistry constituents are presented as the median (50%) CDF in the tables included herein, allowing for comparison of the San Diego region relative to the SCB as a whole. Levels of contamination were also evaluated relative to several previously established sediment quality guidelines. These guidelines include the Effects Range-Low (ERL) and Effects Range-Medium (ERM) sensu Long et al. (1995), and the Threshold Effects Level (TEL) and Probable Effects Level (PEL) sensu MacDonald (1994).

RESULTS AND DISCUSSION

Particle Size Analysis

With few exceptions, the overall composition of sediments off San Diego in 2005 consisted of fine sands and silts (**Figure 8.2, Table 8.2**). The general distribution of sediment particles was similar to that of the previous years: higher sand content in shallow nearshore areas, decreasing to a mixture of mostly coarse silt and very fine sand at the mid-shelf region and deeper offshore sites (see City of San Diego 1998, 2000, 2001, 2002, 2003). However, coarse sediments (~85% sand) occurred in 2 distinct locations: (1) in shallow waters, particularly in the South Bay area, and (2) along the Coronado Bank, a southern rocky ridge located offshore of Point Loma.

Stations along the mid-shelf depth strata (30–120 m) represented most of the shelf region off San Diego (n=24). Sediments at these sites averaged ~61% sand, with a mean particle size of 0.096 mm, and the highest amount of fines (~37%). By comparison, the 7 sites occurring at in shallow water (≤30 m) had coarser sediments with only 8.5% fines and particles with a mean diameter of ~0.262 mm. Sand content at these shallow sites was nearly 83%. Station 2036, with the coarsest sediments (0.987 mm), was among these sites. This station was located near the mouth of San Diego Bay and contained primarily coarse sediments (55%), including coarse sand, relict sands, and shell hash. Five deep water sites (120–200 m) contained sediments of 0.206 mm average particle size, including 73% sand. The deep water strata included 1 fine and 4 coarse sediment stations. The fine sediment site (2028) was located near the shelf-slope interface northwest of the Point Loma Ocean Outfall. It was the deepest station sampled, had the smallest average sediments (0.037 mm), and consisted of 61% fines. The coarse sites (2035, 2041, 2043, 2044) were located along the rocky Coronado Bank.

Exceptions to the above general pattern occurred primarily at several shallow water sites located southward of the entrance to San Diego Bay (stations 2032, 2039, 2046, 2047). These sites were composed of very fine sands composed of more fine materials (~10% fines) relative to other shallow sites in the surrounding area (i.e., stations 2036, 2037). Additionally, 3 mid-shelf stations consisted of primarily coarse sands. Station 2040 was between the EPA designated dredge spoils disposal sites (LA-4 and LA-5), and station 2051 was offshore of the SBOO where relict sands are known to occur. One site north of Point Loma (station 2023) contained over 25% coarse materials including gravel and rock (see **Appendix D.1**). The patchy nature of sediments in these areas has been well documented during previous surveys (see City of San Diego 1998, 2000, 2001, 2002, 2003).

Generally, sediment particle size composition along the San Diego shelf in 2005 was little different than at the same sites sampled in 1995 (Figures 8.2A, B). Only 8 of the 36 stations sampled in 2005 were different by more than 0.05 mm (mean particle size) from the 1995 samples. These sites include 1 shallow water station (2036), 4 mid-shelf stations (2023, 2031, 2040, 2051), and 3 deep water stations (2035, 2041, 2044).

Organic Indicators

As in previous regional surveys, concentrations of TOC and TN tended to increase with depth and decreasing grain size, and were highest at sites along the Coronado Bank and northward where finer sediments were common (**Table 8.2, Figure 8.2**). Mean TOC values were 0.35% at the shallow water stations, but increased to 0.73% at the mid-shelf stations, and 3.87% at the deep shelf sites. The deepest station sampled (2028), had the highest amount of TN, the third highest concentration of sulfides, and fourth highest percent TOC. Stations 2035 and 2041, located along the Coronado Bank, had relatively coarse sediments but the highest levels

Table 8.2

Summary of particle size parameters and organic loading indicators for the 2005 regional survey stations. Data are expressed as station means. MDL=method detection limit. CDF=median cumulative distribution functions (see text); Bolded values exceed the median CDF. Area Mean=mean across all stations.

Station	Depth (m)	Mean (mm)	Fines (%)	Sulfides (ppm)	TN (%)	TOC (%)
Shallow shelf						
2032	12	0.129	11.8	1.8	0.019	0.166
2036	16	0.987	0.0	0.0	0.015	**1.480**
2039	16	0.104	12.7	0.9	0.013	0.127
2046	22	0.122	9.8	0.2	0.012	0.142
2037	24	0.232	5.6	1.1	0.016	0.187
2016	25	0.158	5.0	14.3	0.019	0.179
2047	29	0.101	14.7	0.9	0.016	0.167
Mean	21	0.262	8.5	2.7	0.016	0.350
Mid-shelf						
2049	31	0.099	15.4	1.2	0.015	0.170
2014	38	0.080	28.8	2.0	0.046	0.494
2030	47	0.052	41.7	9.8	**0.068**	**0.835**
2051	49	0.549	2.3	4.4	0.008	0.084
2038	52	0.055	40.0	0.7	**0.056**	0.617
2027	58	0.054	43.2	7.1	**0.067**	0.746
2012	59	0.059	36.0	1.5	**0.053**	0.533
2021	67	0.051	44.9	2.8	**0.072**	**1.050**
2026	68	0.045	54.0	1.0	**0.080**	**0.827**
2042	68	0.090	30.9	1.1	0.047	0.697
2017	69	0.052	41.6	2.6	**0.067**	**0.815**
2022	72	0.051	44.8	1.0	0.066	0.676
2013	73	0.071	29.7	1.4	**0.052**	0.525
2031	74	0.048	49.0	6.4	**0.079**	**0.850**
2034	81	0.044	53.9	1.8	**0.089**	**0.970**
2020	82	0.045	52.3	0.6	**0.094**	**1.500**
2045	84	0.053	39.7	0.8	**0.058**	**0.760**
2018	85	0.044	54.3	1.9	**0.058**	0.733
2023	90	0.210	33.7	1.0	**0.081**	**1.250**
2025	95	0.058	39.9	2.2	**0.071**	**0.783**
2050	101	0.092	22.8	3.8	0.026	0.334
2040	102	0.272	11.3	6.3	**0.065**	**0.808**
2033	104	0.068	31.4	1.1	0.051	**0.834**
2015	108	0.057	38.6	2.7	**0.058**	0.724
Mean	73	0.096	36.7	2.7	0.059	0.734
Deep shelf						
2041	137	0.321	8.5	0.5	**0.065**	**9.020**
2035	152	0.248	13.9	1.5	**0.061**	**5.250**
2043	171	0.273	13.3	1.6	0.044	**1.660**
2044	179	0.151	21.4	0.3	**0.054**	**1.740**
2028	190	0.037	61.4	8.1	**0.121**	**1.660**
Mean	166	0.206	23.7	2.4	0.069	3.866
Area Mean	76	0.143	29.0	2.7	0.052	1.094
MDL				0.14	0.005	0.010
50% CDF					0.051	0.748

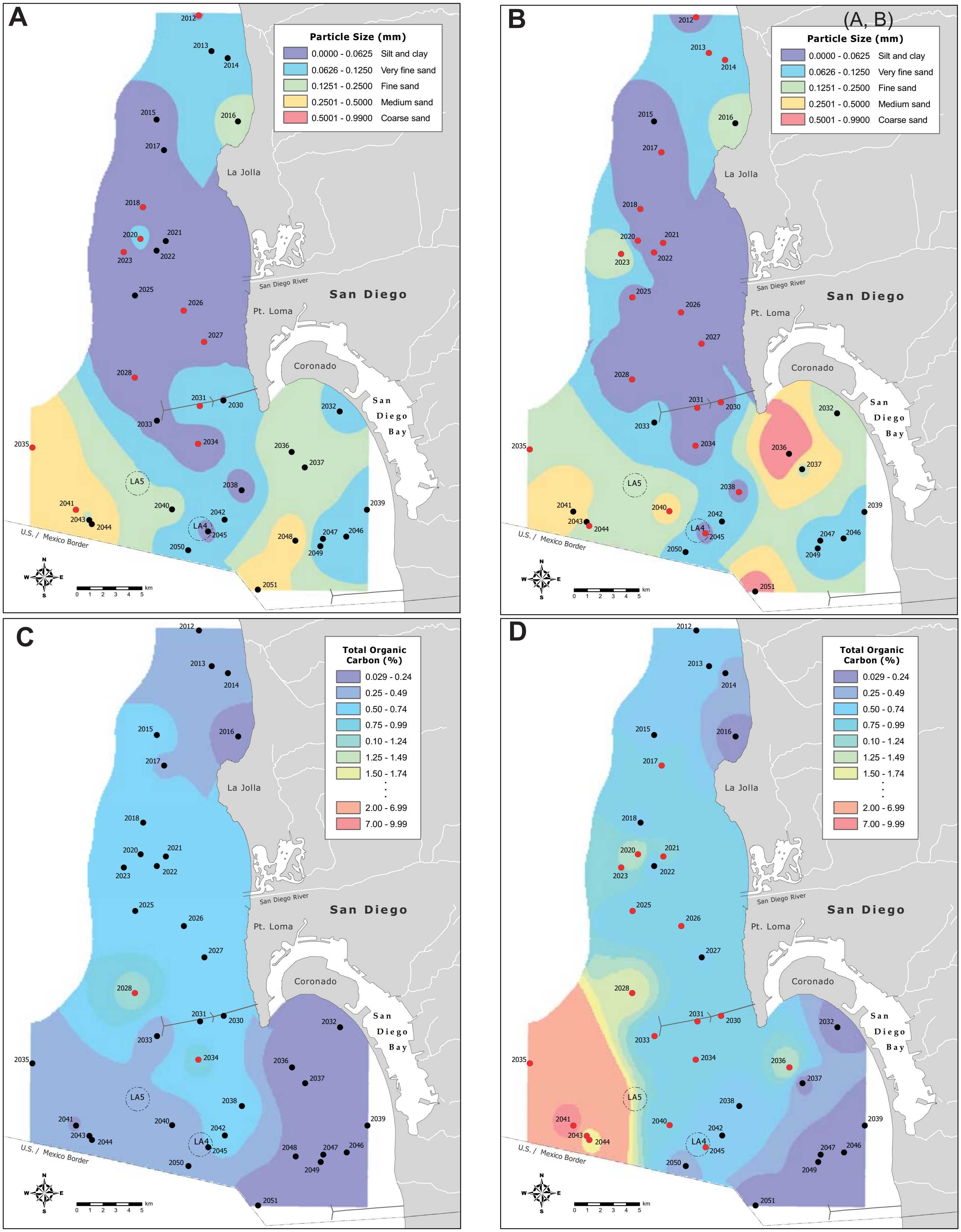

Figure 8.2

Interpolated mean particle size (mm) and TOC (%) data from the regional sediment quality stations sampled off San Diego, CA in July 1995 (A, C) and 2005 (B, D). Sites shown in red include those with concentrations of 3 or more metals (A, B) above the median CDF and individual TOC concentrations (C, D) exceeding the median CDF value.

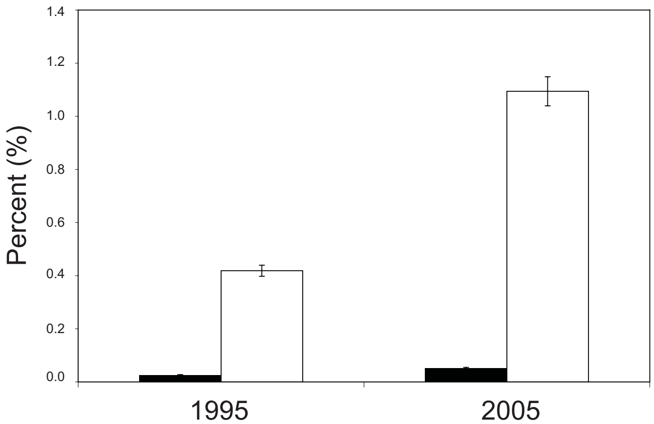

Figure 8.3
Mean concentraion of TOC (white) and TN (black) for the regional survey stations sampled in 1995 versus 2005.

of TOC. The sediments at station 2041 exceeded 6% TOC, an amount associated with severely impacted areas (see Zeng et al. 1995). Both sites had low organic loads in 1995. In contrast, the shallow shelf station 2016 was composed of sediments the greatest amount of sands (94%) with relatively low concentrations of TN and TOC, but the highest concentration of sulfides (14.3 ppm).

In general, concentrations of total organic carbon (TOC) and total nitrogen (TN) in sediment samples collected during 2005 were relatively high compared to prior years (see City of San Diego 1998, 2000, 2001, 2002, 2003). For example, TOC and TN values were over twice as high in 2005 relative to 1995 (**Figure 8.3**). In 2005, approximately 50% of the stations had TOC values that exceeded the median CDF levels, compared to just 5% in 1995 (see Figures 8.2C, D). Similarly, 64% of the TN samples exceeded the median in 2005 relative to 8% in 1995. The cause of the increased organic load is unclear, but may be related to sedimentation resulting from record high rainfall that began in October 2004 and continued through February 2005 (see Chapter 2). For example, there was a large increase in TOC at stations off shore of the Point Loma Ocean Outfall between 2004 and 2005 (see City of San Diego 2006). The resultant storm runoff created large turbidity plumes bearing terrestrial detritus that spread over much of the sampling area. In addition, these circumstances created optimal conditions for the development of large plankton blooms that blanketed the region from April through October 2005. Decaying plankton and terrestrial detritus may have contributed to increased organic content along the shelf (see Mann 1982, Parsons et al. 1990).

Trace Metals

Fourteen trace metals (i.e., aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, tin, and zinc) were detected at almost all 36 survey stations in 2005 (**Table 8.3**). Four metals (i.e., antimony, silver, selenium, and thallium) were detected in one-third or less of the samples. The most widely distributed trace metals appeared to co-vary with iron, a pattern common among many metals found in marine sediments (see Schiff and Gossett 1998). Metal concentrations were generally highest along gradients of increasing depth and decreasing particle size, or near anthropogenic inputs (e.g., ocean outfalls and dredge spoils disposal sites) (**Figure 8.4**). For example, average concentrations for 11 trace metals in the sediments from the mid-shelf strata were higher than either the shallow or deep water strata. Station 2040, located between LA-4 and LA-5 disposal sites, had the highest concentrations of 8 different metals (i.e., arsenic, cadmium, copper, manganese, mercury, silver, tin, and zinc). This is similar to the general pattern of metals contamination that has been found for the SCB (Schiff and Gossett 1998) and in previous regional surveys (see City of San Diego 1998, 2000, 2001, 2002, 2003).

As with organics, concentrations of trace metals in sediments increased between 1995 and 2005 (see Figure 8.4). The sediments at 21 stations sampled in 2005 had 3 or more metals whose concentrations exceeded the median values, which is nearly twice as many as were found in 1995 (see Figure 8.2A, B). Aluminum, beryllium, and iron were the most common trace metals exceeding median CDF values in 2005 (see Table 8.3). However, sediments from several sites contained relatively high amounts of metals associated with industrial (e.g., antimony, beryllium, cadmium, selenium), or that occurred in high concentrations in San Diego Bay (e.g., copper and lead) (City of San Diego 2003b).

Table 8.3

Concentrations of trace metals (parts per million) detected at each 2005 regional survey station. MDL=method detection limit. CDF=median cumulative distribution function (see text). Area Mean=mean across all stations. Values that exceed the median CDF are indicated in bold type. See Appendix A.1 for the names of each metal represented by the periodic table symbol.

Station	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe
Shallow shelf									
2032	8050	**0.24**	2.04	24.2	0.139	0.05	10.7	2.44	9040
2036	2760	**1.08**	3.47	8.1	0.148	nd	4.3	3.61	4680
2039	8600	nd	1.75	26.4	0.162	0.07	14.6	2.42	13400
2046	**10000**	**0.89**	1.48	29.4	0.180	0.05	14.9	2.43	13300
2037	7720	**0.31**	2.76	31.3	0.134	0.04	10.0	3.20	9590
2016	9090	nd	1.34	31.0	0.155	0.09	16.2	2.48	11500
2047	**11700**	nd	1.99	37.5	0.193	0.10	14.3	3.84	10700
Mean	8274	0.36	2.12	26.8	0.159	0.06	12.1	2.92	10316
Mid-shelf									
2049	**9540**	nd	2.04	37.5	0.157	0.06	12.6	4.02	8430
2014	**19200**	nd	3.94	77.1	**0.361**	0.18	24.7	7.95	**19400**
2030	**20000**	nd	3.69	69.1	**0.359**	0.26	25.0	11.40	**19400**
2051	2710	**0.45**	**9.85**	4.6	0.098	0.03	10.4	1.35	8610
2038	**17400**	**0.87**	3.59	52.2	**0.301**	0.15	22.3	8.86	**18400**
2027	**15700**	nd	4.15	58.7	**0.294**	0.26	22.8	10.40	16700
2012	**17100**	**0.25**	4.01	64.0	**0.354**	0.13	24.2	7.11	**19500**
2021	**18000**	nd	3.38	59.9	**0.345**	0.11	24.5	9.19	**19500**
2026	**23600**	nd	**5.01**	76.8	**0.405**	0.17	31.1	11.80	**23400**
2042	8790	nd	2.10	24.5	0.184	0.07	11.4	5.11	9470
2017	**16100**	nd	3.35	62.3	**0.315**	0.13	22.9	7.60	**17800**
2022	**17000**	nd	3.81	50.7	**0.307**	0.09	23.1	8.47	**18300**
2013	**17300**	nd	4.20	62.5	**0.371**	0.16	24.7	7.43	**20200**
2031	**24300**	nd	4.23	81.6	**0.404**	0.19	30.5	11.90	**22700**
2034	**24400**	**0.28**	**4.81**	84.4	**0.409**	0.17	31.1	**15.10**	**24800**
2020	**20900**	nd	4.48	63.5	**0.434**	0.05	30.8	11.40	**23900**
2045	**17400**	**1.27**	3.97	53.5	**0.320**	0.05	23.6	10.40	**18800**
2018	**22200**	**0.46**	4.30	67.7	**0.395**	0.14	30.0	10.70	**22700**
2023	**20900**	nd	**7.69**	142.0	**0.693**	0.20	**39.4**	10.90	**37700**
2025	**18100**	nd	4.02	49.0	**0.329**	0.14	24.4	8.10	**19400**
2050	8480	**0.96**	1.63	24.5	0.186	0.02	13.5	5.14	10400
2040	**24300**	0.15	**26.70**	83.3	**0.441**	**0.90**	**37.2**	**172.00**	**25500**
2033	**11200**	nd	3.44	31.2	**0.269**	0.07	17.1	7.08	13500
2015	**13800**	nd	3.09	185.0	**0.287**	0.17	20.2	7.06	15600
Mean	17018	0.20	5.06	65.2	0.334	0.16	24.1	15.44	18921
Deep shelf									
2041	4980	nd	3.82	14.5	**0.465**	0.18	24.6	7.01	**19300**
2035	7170	nd	**5.38**	20.9	**0.485**	0.07	27.6	4.96	**18200**
2043	4740	nd	2.57	16.8	**0.265**	0.03	14.5	3.20	8110
2044	8640	nd	**7.81**	41.2	**0.586**	**0.34**	**39.7**	5.95	**21200**
2028	**25500**	nd	3.06	75.7	**0.464**	**0.31**	**35.5**	**15.40**	**23600**
Mean	10206	0.00	4.53	33.8	0.453	0.19	28.4	7.30	18082
Area Mean	14281	0.20	4.37	53.0	0.313	0.14	22.1	11.73	16999
MDL	1.15	0.13	0.33	0.002	0.001	0.01	0.016	0.028	0.76
50% CDF	9400	0.2	4.8	na	0.26	0.29	34	12	16800

Table 8.3 continued

Concentrations of trace metals (parts per million) detected at each 2005 regional survey station. MDL=method detection limit. CDF=median cumulative distribution function (see text). Area Mean=mean across all stations. Values that exceed the median CDF are indicated in bold type. See Appendix A.1 for the names of each metal represented by the periodic table symbol.

Station	Pb	Mn	Hg	Ni	Se	Ag	Ti	Sn	Zn
Shallow shelf									
2032	2.93	178	0.005	2.89	nd	0.054	nd	1.56	19.1
2036	3.08	80	0.007	0.73	nd	**0.403**	nd	1.00	7.4
2039	3.39	348	0.005	3.28	nd	nd	nd	1.58	23.9
2046	2.62	350	0.003	3.37	nd	0.135	nd	1.61	25.5
2037	6.33	145	0.009	2.84	nd	0.094	0.32	1.46	20.6
2016	2.69	322	0.003	3.79	nd	nd	nd	1.19	22.5
2047	3.36	177	0.007	4.70	nd	nd	nd	1.21	23.8
Mean	3.49	229	0.006	3.09	0.00	0.098	0.05	1.37	20.4
Mid-shelf									
2049	2.62	105	0.005	4.29	nd	nd	nd	1.20	19.9
2014	6.93	313	0.008	7.91	nd	nd	nd	2.23	46.3
2030	10.00	286	**0.053**	10.80	nd	nd	nd	2.88	50.6
2051	3.59	57	nd	0.98	nd	0.084	nd	0.93	8.4
2038	7.03	263	0.037	9.41	nd	0.145	nd	2.56	39.3
2027	8.48	219	**0.071**	9.49	nd	0.024	nd	2.62	42.1
2012	7.96	279	0.015	7.66	nd	nd	nd	2.49	41.7
2021	8.12	290	0.035	9.32	nd	nd	nd	2.31	44.9
2026	10.90	335	**0.064**	12.20	**0.316**	nd	nd	3.42	52.9
2042	4.33	152	0.022	5.05	nd	nd	nd	1.64	21.3
2017	7.84	279	0.027	8.27	nd	nd	nd	2.34	40.7
2022	8.37	267	0.033	8.64	nd	nd	nd	2.09	53.4
2013	7.77	260	0.014	7.77	nd	nd	nd	2.07	44.6
2031	11.60	336	**0.048**	12.40	nd	nd	nd	3.28	54.2
2034	10.10	307	**0.142**	13.50	nd	0.066	nd	2.93	**56.9**
2020	9.31	283	**0.046**	11.70	0.122	nd	nd	2.82	52.8
2045	7.48	269	**0.052**	10.40	nd	**0.190**	nd	2.52	41.7
2018	11.10	325	**0.043**	11.20	nd	nd	nd	2.66	50.4
2023	9.66	258	**0.040**	12.20	nd	nd	nd	2.58	**61.3**
2025	7.18	318	0.035	9.53	nd	nd	nd	2.68	40.9
2050	4.04	200	**0.077**	5.80	nd	0.143	nd	1.74	23.2
2040	154.00	290	**16.800**	11.30	0.215	**1.200**	nd	6.93	**180.0**
2033	4.83	164	0.024	7.01	nd	nd	nd	1.63	29.7
2015	6.03	214	0.031	7.63	nd	nd	nd	1.76	34.9
Mean	13.72	253	0.738	8.94	0.03	0.08	0.00	2.51	47.2
Deep shelf									
2041	8.48	32	0.015	5.38	0.277	nd	nd	0.75	34.2
2035	6.16	86	0.016	5.77	0.282	nd	nd	1.38	31.3
2043	4.07	47	0.016	3.87	**0.346**	nd	nd	1.29	14.1
2044	7.50	78	**0.052**	7.51	0.00	nd	nd	3.32	26.4
2028	9.28	310	**0.057**	16.90	**0.374**	nd	n	3.51	**57.8**
Mean	7.10	111	0.031	7.89	0.26	0.00	0.00	2.05	32.8
Area Mean	10.69	229	0.491	7.57	0.05	0.07	0.01	2.21	39.6
MDL	0.14	0.004	0.003	0.036	0.24	0.013	0.22	0.06	0.05
50% CDF	na	na	0.04	na	0.29	0.17	na	na	56

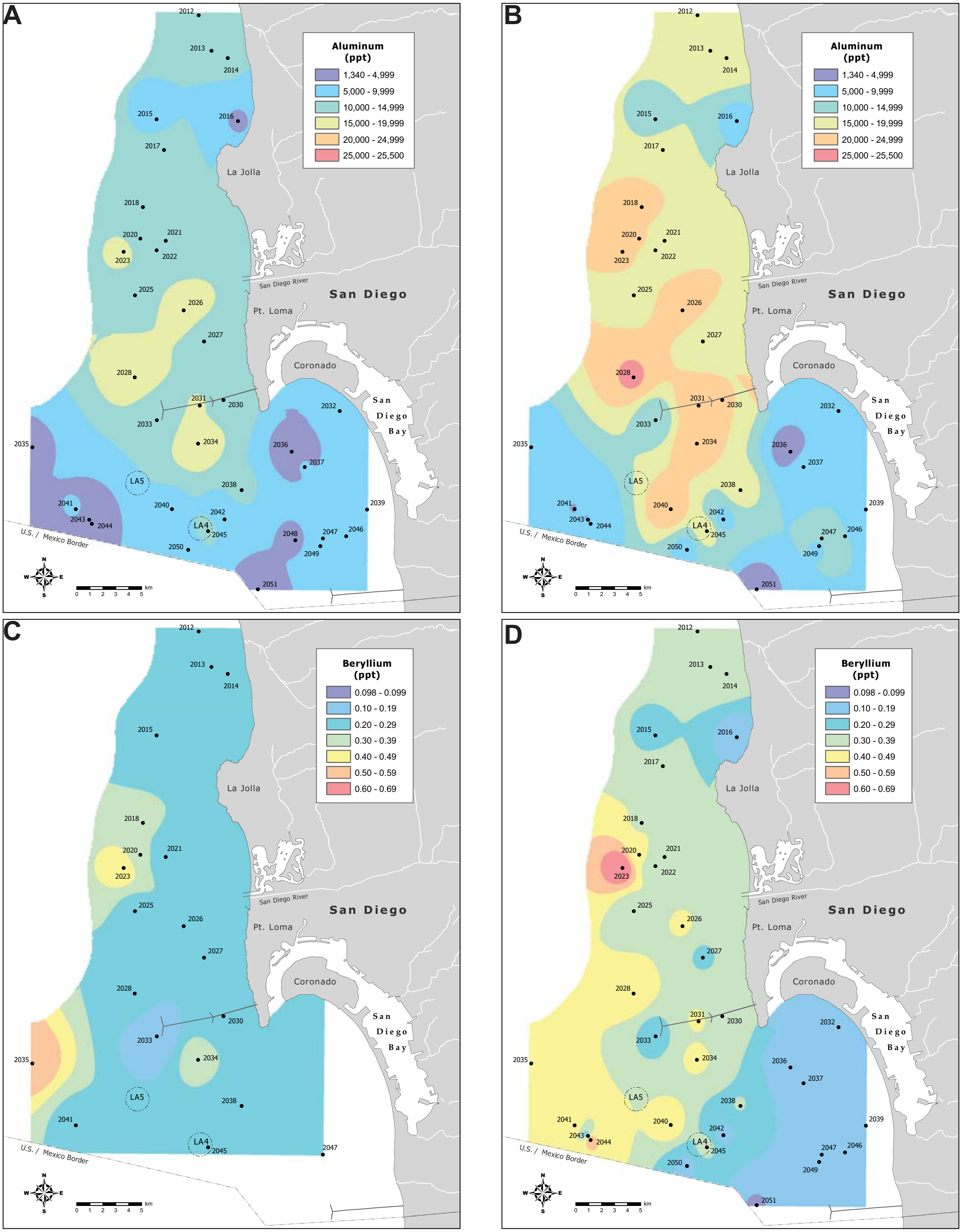

Figure 8.4

Interpolated aluminum and beryllium concentrations (ppt) from the regional sediment quality stations sampled off San Diego, CA in July 1995 (A, C) and 2005 (B, D).

Beryllium was the most widespread of these metals. It exceeded the median CDF at 25 stations in 2005, primarily at mid-shelf and deep water sites. However, 4 of the 10 sites with 2 or more of these industrial-use metals above the median were located near or around LA-4 and LA-5 dredge spoils sites (2034, 2038, 2040, 2045). Two others occurred farther offshore along the Coronado Bank (stations 2043, 2044). Sediments at 5 stations included concentrations of several metals above the TEL: station 2023 (arsenic), station 2028 (nickel), station 2034 (mercury), station 2040 (arsenic and mercury), and station 2044 (arsenic).

Other Contaminants: Pesticides, PCBs and PAHs

Pesticides and PCBs were detected rarely during 2005, while PAHs occurred at every station in low concentrations (Table 8.4). No sample exceeded the 50% CDF for either contaminant. Total DDT (the sum of several metabolites) was detected at 3 sites located near the head of La Jolla Canyon (i.e., stations 2013, 2015, 2016) and 1 site near the LA-4 disposal site (i.e., 2045). PCBs were detected at station 2023, a northern site located near the continental shelf-slope interface. The two stations with the PAH highest concentrations and relatively high numbers of PAH compounds included the deepest site (2028) and the one station (2040) located between the two dredge spoils disposal area (LA-4 and LA-5). The increased frequency of detection in PAHs was due to a change in methodology and instrumentation, not to an increase in sediment load. In general, PAH, PCB, and pesticide concentrations have been relatively low in the sediments along the mainland shelf off San Diego compared to other sites in the SCB (see City of San Diego 1998, 2000, 2001, 2002, 2003).

SUMMARY AND CONCLUSIONS

Although the presence of canyons, peninsulas, bays, and alluvial fans from rivers contribute to

Table 8.4
Mean concentrations for total DDT, total PCBs, and total PAHs, including the number of PAH compounds detected at each 2005 regional survey station. CDF=median cumulative distribution function (see text). Undetected values are indicated by "nd."

Station	Total DDT	Total PCBs	Total PAH	
	(ppt)	(ppt)	(ppt)	Number
Shallow shelf				
2032	nd	nd	133	8
2036	nd	nd	159	11
2039	nd	nd	188	15
2046	nd	nd	126	6
2037	nd	nd	153	8
2016	630	nd	128	8
2047	nd	nd	142	6
Mid-shelf				
2049	nd	nd	150	7
2014	nd	nd	167	6
2030	nd	nd	320	11
2051	nd	nd	131	8
2038	nd	nd	199	9
2027	nd	nd	185	6
2012	nd	nd	185	6
2021	nd	nd	67	6
2026	nd	nd	173	6
2042	nd	nd	132	9
2017	nd	nd	368	11
2022	nd	nd	267	9
2013	350	nd	219	9
2031	nd	nd	339	12
2034	nd	nd	309	9
2020	nd	nd	346	11
2045	400	nd	301	11
2018	nd	nd	295	9
2023	nd	1380	149	7
2025	nd	nd	178	7
2050	nd	nd	143	7
2040	nd	nd	946	14
2033	nd	nd	227	8
2015	700	nd	199	9
Deep shelf				
2041	nd	nd	250	8
2035	nd	nd	158	7
2043	nd	nd	120	5
2044	nd	nd	141	7
2028	nd	nd	521	13
50%CDF	1200	2600	—	—

the complexity of sediment composition and origin along the San Diego shelf (see Emery 1960), the distribution of sediment particles off San Diego in 2005 was similar to that of previous years and to the Southern California Bight (SCB) in general. There was a trend towards higher sand content in shallow nearshore areas and increased fine sand and silt at the deeper offshore sites. For example, stations ≤30 m in depth averaged the most amount of sand (83%), while stations along the mid-shelf (30–120 m) averaged the least sand (61%) and the highest fines (37%). The deep shelf stations (120–200 m) included 4 coarse sediment stations located along the Coronado Bank and 1 soft sediment station northwest of the Point Loma Ocean Outfall. Collectively, these sites averaged 73% sand and 24% fines; however, the deepest site had the most fines of any station sampled (61%). Exceptions to the general pattern occurred at several shallow water sites located southward of the entrance to San Diego Bay. These sites contained more fine materials relative to other shallow sites in the surrounding area. Additionally, 3 mid-shelf stations contained coarse sediments relative to the other mid-shelf stations: 1 site located between the EPA designated dredge spoils disposal sites (LA-4 and LA-5); 1 offshore of the South Bay Ocean Outfall (SBOO) where relict sediments are typical; and 1 northern site near the shelf-slope interface.

Overall, the majority of the San Diego mainland shelf consists of predominantly fine sediments, with coarse sediments occurred in shallow waters, particularly in the South Bay area, and along the Coronado Bank, a southern rocky ridge located offshore of Point Loma. There has been little change in sediment composition or average particle size since 1995 when these sites were first sampled. Only 8 of the 36 revisited sites changed in mean particle size between the two surveys. Although several sights contained coarse sands and gravel, there was little evidence of anthropogenic impacts in sediment particle size data collected during the 2005 regional survey.

Patterns in sediment chemistries followed the expected relationship of rising concentrations with decreasing particle size and increasing depth (see Emery 1960, Anderson et al. 1993, Schiff and Gossett 1998). However, in contrast to particle size, sediment chemistries did show evidence of natural and anthropogenic impacts in the region. For example, 5 sites had metals concentration above TEL sediment quality guideline, and one site contained TOC load high enough to be considered severely impacted (see Zeng, et al. 1995). In addition, the concentrations of various constituents (e.g., TOC, TN, trace metals) were substantially higher in 2005 relative to 1995. Only a few stations had sediments with concentrations of TN or TOC above Bight-wide median CDF values in 1995, while over 60% of the stations exceeded these benchmark values in 2005. Similarly, 11 stations had concentrations of 3 or more metals that exceeded the median CDF in 1995, while 21 stations did so in 2005. Some of this increase may be related to record rainfall, storm water runoff, and turbidity plumes that spread over much of the sampling area in late 2004 and early 2005. Discharges from the San Diego and Tijuana Rivers as well as Mission Bay and San Diego Bay could have contributed to the observed increases in organic and trace metal contamination. In addition, some naturally occurring and prevalent trace metals, such as aluminum and iron, are also used in the wastewater treatment process. One station located between LA-4 and LA-5 dredge spoils disposal sites had the highest concentration of 8 different metals, several of which (arsenic, copper, manganese, and zinc) were also found in high concentrations within San Diego Bay (City of San Diego 2003b). While the source of the increased organic and trace metals concentrations is unknown, it may well be a combination of natural and anthropogenic affects.

Although contamination of other types (e.g., pesticides, PCBs, PAHs) was generally low in 2005, the pattern of detection was similar to that seen previously. PCBs were detected a northern site located near the continental shelf-slope interface and derivatives of DDT were detected at several northern stations near the head of La Jolla Canyon and 1 site near LA-4. Similarly, PAH contamination was more common near the dredged materials disposal sites, as has been the case in past surveys.

Finally, the regional survey data did not show any pattern of contamination relative to wastewater discharge from the SBOO. Contaminant levels at the shallow stations included in the SBOO sampling grid were similar to the shallow regional survey samples, whereas sediments at the 38 and 55 m stations had lower levels of organics or trace metals than comparable mid-shelf stations.

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